

WHAT IS CLAIMED IS:

1 1. An amorphous computing system for computing seismic images, the
2 system comprising:

3 a first amorphous hardware element;

4 a computer processor communicably coupled to the amorphous hardware
5 element and to a computer readable medium, wherein the computer readable medium
6 includes instructions executable by the computer processor to:

7 define a first plurality of hardware gates associated with the amorphous
8 hardware element to form a first processing pipeline, wherein the first processing pipeline is
9 operable to update a first seismic image point; and

10 define a second plurality of hardware gates associated with the
11 amorphous hardware element to form a second processing pipeline, wherein the second
12 processing pipeline is operable to update a second seismic image point independent of the
13 first processing pipeline.

1 2. The system of claim 1, wherein the computer readable medium further
2 includes a set of coefficients for a high frequency filter corresponding to a threshold noise
3 frequency and a set of coefficients for a sinc filter.

1 3. The system of claim 2, wherein the first processing pipeline and the
2 second processing pipeline include functions operable to implement at least some elements of
3 a Kirchhoff algorithm, and wherein the functions include:

4 a first function, wherein the first function interpolates a velocity function to
5 calculate a velocity at an image point;

6 a second function, wherein the second function utilizes the velocity to
7 calculate a time of the data trace that contributes to the image point;

8 a third function, wherein the third function utilizes the time of the data trace to
9 calculate a real sample number of the data trace, and wherein the real sample number of the
10 data trace is a fractional offset from a whole sample number of the data trace;

11 a fourth function, wherein the fourth function filters a plurality of whole
12 sample numbers of the data trace that straddle the real sample number of the data trace using
13 the set of coefficients for a high frequency filter;

14 a fifth function, wherein the fifth function uses the set of coefficients for a sinc
15 filter to interpolate the filtered plurality of whole number samples to the real sample number;
16 and
17 a sixth function, wherein the sixth function sums the output of the fifth
18 function into an output trace at the image point.

1 4. The system of claim 1, wherein the first processing pipeline and the
2 second processing pipeline include functions operable to implement at least some elements of
3 a Wave Equation, and wherein the functions include:
4 an update function, wherein the update function creates a set of simultaneous
5 equations that will distribute energy from the data trace to a set of output image points
6 located on an x,y,z coordinate grid;
7 a tri-diagonal solver function, wherein the tri-diagonal solver function solves
8 the set of simultaneous functions; and
9 a thin lense adjustment function, wherein the thin lense adjustment function
10 compensates for a lateral velocity gradient.

1 5. The system of claim 1, wherein the amorphous hardware element is a
2 first field programmable gate array, and wherein the system further comprises:
3 a second field programmable gate array communicably coupled to the
4 computer processor, wherein the computer readable medium further includes instructions
5 executable by the computer processor to:
6 define a third plurality of hardware gates within the second field
7 programmable gate array to form a third processing pipeline, wherein the third processing
8 pipeline is operable to update a third seismic image point independent of the first processing
9 pipeline and the second processing pipeline.

1 6. The system of claim 1, wherein the amorphous hardware element is a
2 field programmable gate array; and wherein the computer processor is a reduced instruction
3 set computer processor.

1 7. A method for processing seismic data traces within an amorphous
2 hardware element, the method comprising:
3 providing an amorphous hardware element;

4 providing a computer processor communicably coupled to the amorphous
5 hardware element and to a computer readable medium;

6 programming the amorphous hardware element; wherein programming the
7 amorphous hardware element includes defining the amorphous hardware element to
8 implement at least a portion of a seismic imaging algorithm.

1 8. The method of claim 7, wherein the at least a portion of the seismic
2 imaging algorithm includes elements of Kirchhoff algorithm.

1 9. The method of claim 8, wherein the method further comprises:
2 providing a set of coefficients for a high frequency filter corresponding to a
3 threshold noise frequency and a set of coefficients for a sinc filter.

1 10. The method of claim 9, wherein programming the amorphous
2 hardware element includes defining a processing pipeline including functions operable to
3 implement the elements of the Kirchhoff algorithm, and wherein the functions include:
4 a first function, wherein the first function interpolates a velocity function to
5 calculate a velocity at an image point;
6 a second function, wherein the second function utilizes the velocity to
7 calculate a time of the data trace that contributes to the image point;
8 a third function, wherein the third function utilizes the time of the data trace to
9 calculate a real sample number of the data trace, and wherein the real sample number of the
10 data trace is a fractional offset from a whole sample number of the data trace;
11 a fourth function, wherein the fourth function filters a plurality of whole
12 sample numbers of the data trace that straddle the real sample number of the data trace using
13 the set of coefficients for a high frequency filter;
14 a fifth function, wherein the fifth function uses the set of coefficients for a sinc
15 filter to interpolate the filtered plurality of whole number samples to the real sample number;
16 and
17 a sixth function, wherein the sixth function sums the output of the fifth
18 function into an output trace at the image point.

1 11. The method of claim 7, wherein the at least a portion of the seismic
2 imaging algorithm includes elements of Wave Equation.

1 12. The method of claim 11, wherein programming the amorphous
2 hardware element includes defining a processing pipeline including functions operable to
3 implement the elements of the Wave Equation, and wherein the functions include:
4 an update function, wherein the update function creates a set of simultaneous
5 equations that will distribute energy from the data trace to a set of output image points
6 located on an x,y,z coordinate grid;
7 a tri-diagonal solver function, wherein the tri-diagonal solver function solves
8 the set of simultaneous functions; and
9 a thin lense adjustment function, wherein the thin lense adjustment function
10 compensates for a lateral velocity gradient.

1 13. The method of claim 7, wherein programming the amorphous
2 hardware element comprises defining a plurality of hardware gates within the amorphous
3 hardware element to form at least one processing pipeline.

1 14. The method of claim 7, wherein programming the amorphous
2 hardware element comprises defining a first plurality of hardware gates within the amorphous
3 hardware element to form a first processing pipeline, and defining a second plurality of
4 hardware gates within the amorphous hardware element to form a second processing pipeline.

1 15. The method of claim 14, wherein the first processing pipeline is
2 operable to update a first seismic image point, and the second processing pipeline is operable
3 to update a second seismic image point.

1 16. The method of claim 15, wherein the first processing pipeline operates
2 independent of the second processing pipeline.

1 17. The method of claim 7, wherein the amorphous hardware element is a
2 field programmable gate array; and wherein the computer processor is a reduced instruction
3 set computer processor.

1 18. The method of claim 7, wherein programming the amorphous
2 hardware element comprises defining a plurality of hardware gates within the amorphous
3 hardware element to form a plurality of processing pipelines, and wherein each of the

4 respective processing pipelines within the plurality of processing pipelines is operable to
5 update a seismic image point in parallel to others of the respective processing pipelines.

1 19. The method of claim 7, wherein the amorphous hardware element is
2 included within a first field programmable gate array, and wherein programming the
3 amorphous hardware element comprises defining a first plurality of hardware gates within the
4 field programmable gate array to form a first processing pipeline, the method further
5 comprising:

6 providing a second amorphous hardware element communicably coupled to
7 the computer processor; and

8 programming the second amorphous hardware element, wherein programming
9 the second amorphous hardware element comprises defining a second plurality of hardware
10 gates within the field programmable gate array to form another processing pipeline.

1 20. A system for implementing a Kirchhoff algorithm, the system
2 comprising:

3 a field programmable gate array;

4 a computer processor communicably coupled to the field programmable gate
5 array and to a computer readable medium, wherein the computer readable medium includes a
6 set of coefficients for a high frequency filter corresponding to a threshold noise frequency
7 and a set of coefficients for a sinc filter, and instructions executable by the computer
8 processor to:

9 define a first plurality of hardware gates within the field programmable
10 gate array to form a first processing pipeline, wherein the first processing pipeline is operable
11 to update a first seismic image point, and wherein the first processing pipeline implements
12 the following functions:

13 a first function, wherein the first function interpolates a velocity
14 function to calculate a velocity at an image point;

15 a second function, wherein the second function utilizes the
16 velocity to calculate a time of the data trace that contributes to the image point;

17 a third function, wherein the third function utilizes the time of
18 the data trace to calculate a real sample number of the data trace, and wherein the real sample
19 number of the data trace is a fractional offset from a whole sample number of the data trace;

20 a fourth function, wherein the fourth function filters a plurality
 21 of whole sample numbers of the data trace that straddle the real sample number of the data
 22 trace using the set of coefficients for a high frequency filter;
 23 a fifth function, wherein the fifth function uses the set of
 24 coefficients for a sinc filter to interpolate the filtered plurality of whole number samples to
 25 the real sample number;
 26 a sixth function, wherein the sixth function sums the output of
 27 the fifth function into an output trace at the image point;
 28 define a second plurality of hardware gates within the field
 29 programmable gate array to form a second processing pipeline, wherein the second
 30 processing pipeline is operable to update a second seismic image point independent of the
 31 first processing pipeline, and wherein the second processing pipeline implements the
 32 following functions:
 33 the first function, wherein the first function interpolates a
 34 velocity function to calculate a velocity at an image point;
 35 the second function, wherein the second function utilizes the
 36 velocity to calculate a time of the data trace that contributes to the image point;
 37 the third function, wherein the third function utilizes the time of
 38 the data trace to calculate a real sample number of the data trace, and wherein the real sample
 39 number of the data trace is a fractional offset from a whole sample number of the data trace;
 40 the fourth function, wherein the fourth function filters a
 41 plurality of whole sample numbers of the data trace that straddle the real sample number of
 42 the data trace using the set of coefficients for a high frequency filter;
 43 the fifth function, wherein the fifth function uses the set of
 44 coefficients for a sinc filter to interpolate the filtered plurality of whole number samples to
 45 the real sample number; and
 46 the sixth function, wherein the sixth function sums the output
 47 of the fifth function into an output trace at the image point.